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CALFED Science Program Expert Review Panel: Hydrodynamics and Salinity Response to Levee Breaches in the Suisun Marsh

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Introduction

The CALFED Ecosystem Restoration Program Plan (ERPP, 1999) stated a goal of restoring tidal action to 5000 – 7000 acres in Suisun Bay and Marsh. While restoring tidally influenced habitat is widely considered ecologically beneficial, the effects on salinity of such actions had not previously been extensively considered.

Recent modeling completed by the Department of Water Resources (DWR) suggests that salinities could be altered significantly by restoring tidal influence to large tracts of land in the Suisun Marsh or Delta. These provocative results brought up many questions regarding the modeling itself and the implications of the results. First, are the salinity results realistic? And, if so, could situations be properly modeled and implemented that benefited both the ecology and water quality of the Bay-Delta Estuary? What design issues for breaching levees for restoration are important to water quality? That is, how important is the "how big," "how," and "where" of restoration? And finally, can the results somehow be tested in the field?

CALFED, in cooperation with DWR and the U.S. Geological Survey (USGS), hosted a Science Program expert review panel workshop on *Hydrodynamics and Salinity Response to Levee Breaches in the Suisun Marsh* on June 27 - 28, 2001 to address the above questions. The purpose of the panel review and workshop was to (1) present relevant technical issues to the expert panel members, (2) obtain public input to the review process, and (3) obtain direction from panel members on future research and modeling needs. The panel is considering public input, modeling, and data analysis.

Background

The CALFED Suisun Marsh Levee Investigation Team

Extensive levee breaching and overtopping occurred in Suisun Marsh during winter storms in February 1998 prompting DWR to conduct modeling studies assessing the effects on water quality in the Marsh and Delta. Results of the modeling indicated that levee breaches in the Marsh tend to increase salinity in the region of the breach but may decrease it far from the breach when breach opening is kept relatively small. However, if breach openings were left unrepaired and allowed to widen, water quality tends to decrease across the entire system.

These studies showed the importance of the Suisun Marsh to Delta water quality and prompted CALFED to participate in additional investigations into this relationship. The CALFED Suisun Marsh Levee Investigation Team (SMLIT) was established to determine if Marsh levees should be included in the CALFED program and, if so, if there are opportunities for ecosystem restoration in the Marsh and water quality improvements in the Marsh and Delta. Studies conducted by the SMLIT showed that levee breaches in the Suisun Marsh can have significant impacts on the currents, tidal prism, and salinity regime of the Bay and Delta. Conversely, engineered levee breaches, in concert with innovative levee designs, may reduce Delta salinity while advancing ecosystem restoration goals and protecting existing waterfowl habitat.

The SMLIT has completed their final report which will serve as a technical appendix to the Suisun Marsh Charter Group's Implementation Plan. In the report, the SMLIT concluded that protection

of Suisun Marsh levees is critical for Delta salinity control and that additional opportunities exist for improving water quality and enhancing habitat.

The Suisun Marsh Charter Team

Concurrent with CALFED's investigations of the Marsh, interested agencies were coming together to develop a plan for implementing CALFED goals, water project mitigation responsibilities, and endangered species conservation for the Marsh. In the past, state, local, federal, and landowner agencies have had conflicting ideas of what the Marsh should look like in the future. The Charter Group was formed to address the interests of all the parties and devise a unified direction and plan for the Marsh. The Charter Group is creating an Implementation Plan to improve the existing and restored habitats of the Marsh. Rigorously reviewed modeling will be beneficial in the future to studies and projects falling under the Charter Group's plan.

The CALFED Science Program and Expert Panel

The CALFED Science Program serves as a forum for review of technical scientific issues pertinent to CALFED studies. The Science Program strives to establish world-class science through unbiased, relevant, authoritative, integrated, and communicated science. The Science Program began in 1999 and Dr. Samuel N. Luoma was named Lead Scientist at that time. Dr. Luoma stated at the workshop that CALFED science should be "unquestionably of the highest quality and unquestionably balanced" so that policy-makers can make informed decisions.

The SMLIT requested that the Science Program assemble and support an expert panel to review their modeling methods and conclusions. In selecting the members of the panel it was acknowledged that they must be distinguished in their field and highly knowledgeable of estuarine hydrodynamics modeling and/or processes. The Science Program also felt it was important to bring in an outside expert who does not currently work in the Bay-Delta Estuary and could perhaps lend a new perspective to the panel. The panel consists of:

> Jon Burau, USGS – Jon Burau is a project chief with the U.S. Geological Survey with 15 years experience studying the hydrodynamics of North Bay and the Delta. Jon's research the last few years has focused on field investigations of estuarine physics with an emphasis on tidal and residual circulation, and the transport and fate of salinity, suspended sediment, and non-motile organisms. Examples of specific studies include the "Entrapment Zone" studies of the late 1990's, dye/fish migration studies in the south Delta, investigations of shallow water habitats, such as Honker and Grizzly Bays and Sherman Lake, and more recently, salmon migration studies at the Delta Cross Channel and at the Head of Old River.
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> Richard Denton, Contra Costa Water District (CCWD) -- Richard Denton is the Water Resources Manager of the Water Resources Division at the CCWD. Richard has participated in Bay-Delta workgroups, hearings and other proceedings since 1989. He has had extensive experience modeling and analyzing Central Valley operations and flow and salinity regimes in Sacramento-San Joaquin Delta. In 1995, Dr. Denton received the first annual Hugo B. Fischer Award from the California Bay-Delta Modeling Forum in recognition of his development and innovative application of a salinity-outflow model for the Sacramento-San Joaquin Delta.
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> Rocky Geyer, Woods Hole Oceanographic Institute (WHOI)-- W. Rockwell Geyer is a Senior Scientist at WHOI specializing in estuarine and coastal transport processes, with particular interest in stratified flow dynamics and sediment transport. He has worked in many different estuaries and coastal environments, including the Amazon, the Pacific Northwest, New England, the Hudson River, the Eel River, and the western Gulf of Maine. His research includes a blend of observational, process-studies and numerical modeling, directed both at basic research questions and applied problems of societal concern, such as harmful algal blooms and contaminant transport.
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> Mark Stacey, UC Berkeley -- Mark Stacey is an Assistant Professor in Environmental Engineering at the University of California-Berkeley, specializing in Environmental Fluid Mechanics. His research focuses on the dynamics of stratified environments, particularly tidally-driven estuaries, with much of his work examining San Francisco Bay. Dr. Stacey's recent Ph.D. dissertation was on Turbulence Processes in Suisun Bay.

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The CALFED Science Panel Review Process

The Levee Breach Panel Review Process includes several sessions scheduled for summer and early fall 2001. The Panel received modeling results and mechanisms analyses several months prior to the workshop. The June 27 - 28th workshop was the kick-off session to present the modeling results and relevant field data to the panel and the general public. The first day of the workshop focused on informing and obtaining input from the public. The second day was a smaller session to discuss the details of the modeling and to task out future modeling requirements based partly on the public input received. Email facilitates regular group discussion amongst the panel members and modelers. Subsequent meetings and workshops will further scope out the model attributes needed to appropriately simulate levee breach scenarios.

The Workshop

Mr. Larry Smith, USGS, and Chris Enright, DWR, organized and co-chaired the workshop. The workshop was opened by Curt Schmutte, DWR Suisun Marsh Branch Chief, and Dr. Luoma, lead scientist of the CALFED Science Program. Mr. Schmutte emphasized the need for collaboration and coordination between the four primary CALFED programs, Ecosystem Restoration, Water Supply Reliability, Flood Control, and Water Quality, in solution design. He also stated that we are evaluating the potential to do what otherwise would take a "billion-dollar reservoir to do in terms of Delta outflow, water quality, and water supply reliability." Mr. Schmutte acknowledged the importance of peer review and stakeholder acceptance of the modeling so that it can be effectively used for problem solving and design.

Dr. Luoma placed the importance of accurate hydrodynamics and water quality modeling in the broader perspective of CALFED. He stated that the "Suisun Marsh and central Delta are crucial parts for all four of these [CALFED] goals" and the initial modeling runs under evaluation show that these locations are "where some of the most important interconnections and complexities can occur." He emphasized the purpose of the workshop is a combination of peer-review and openness. It should also assist in determining what should be done in the future and how we can better communicate the findings to others. Although the studies under consideration have occurred over the past two years, it is important to recognize that this is the beginning of a process, not the end, since a successful review will spawn new ideas for study.

To focus the workshop Mr. Smith posed three specific questions to the panel and workshop attendees for consideration:

1 – What evidence exists that levee breaches in the Suisun Bay and Marsh area influence Delta salinities?
2 – What are the candidate physical mechanisms that might explain these influences?
3 – What science is necessary to select or reject any of these candidate mechanisms?

Summary of Levee Breach Modeling Results

Two presentations were made on levee breach modeling to assist in answering the above questions. Mr. Enright presented one-dimensional model results from DWR's Delta Simulation Model 1 (DSM1) and DSM2. John DeGeorge, Resource Management Associates (RMA), presented two-dimensional modeling results from the RMA model. All three models, though functionally quite different, resulted in similar salinity trends. Each of the models showed that breaches in the Suisun Bay and Marsh can significantly affect Delta salinities.

After discussing results, both presenters focused on two competing mechanisms creating the salinity trends exhibited by the models. These two mechanisms are tidal asymmetry and tidal

range reduction. While tidal asymmetry caused by a breach with a small opening tends to increase salinity mixing, tidal range reduction due to opening a new area to tidal flow tends to decrease salinity mixing.

Relevant Hydrodynamic Analyses

Mr. Jon Burau, USGS, and Dr. Jessica Lacy, USGS Coastal and Marine Geology, highlighted results of field work in the context of the breach questions. Mr. Burau presented data showing the baroclinic flow patterns in the Bay and Marsh. While baroclinicity is strong in the San Pablo Bay, it is not particularly strong in Suisun Bay. However, if breaches in the Marsh are affecting tidal energy, they could be affecting the baroclinicity. Changes to tidal energy and the resulting effect on salinity supply could significantly affect the real-world effects of breaches. Mr. Burau also presented data supporting the large flow exchanges that are possible through shallow water habitat areas such as Sherman Lake, and evidence of gravitational circulation in Montezuma Slough.

Dr. Lacy's presentation was titled "How do circulation and transport in shallows and channels differ?" Her field study focused on the complicated circulation patterns of Honker Bay and Suisun Cutoff. She concludes that Honker Bay is not well-mixed laterally. Because of Honker Bay's semi-enclosed configuration, it's contribution to dispersion is greater than for an open shoal. This field data could imply that at least a two-dimensional model is needed to capture this longitudinal variation.

Group and Panel Discussion

After the presentations, workshop attendees and panel members were given the opportunity to comment. Key questions from the audience included:

- What are the biological and ecological implications of the model results?
- What are the effects of geometry changes over time, such as sedimentation or breach size?
- Are the models applicable to other areas (e.g., breaches in San Pablo Bay or Delta)?
- What are the cumulative effects of numerous projects in the San Francisco Bay Estuary?

The panel emphasized the need to further utilize existing field data for additional validation and calibration through historical comparisons. Several specific suggestions were made for additional hydrodynamics analysis to elucidate the potential mechanisms of mixing in the system.

Future actions to further improve the modeling capabilities were drafted out in a phased, three-year plan. These actions include calibration/validation activities, mechanisms investigations, and data collection efforts. The panel encouraged use of a three-dimensional model for comparison to the modeling done thus far.

Conclusions

The focus questions initially posed to the panel and workshop attendees were answered, in brief, as:

1 – Modeling and field evidence show that levee breaches in the Suisun Bay and Marsh *do* affect Delta salinities.
2 – Candidate physical mechanisms could include tidal asymmetry, tidal range reduction, baroclinicity effects, and tidal energy changes.

3 – Additional science would assist in further identifying key candidate mechanisms for salinity mixing. Mechanisms should be examined using classical tidal hydrodynamics analysis techniques in concert with comparisons to field data sets.

As evidence to the success of the workshop in spawning new ideas, many new questions were raised over the course of the two-day review. The ongoing Science Program review is providing an invaluable process to further the hydrodynamics modeling of the Estuary. Ultimately, this process should provide manager's and planner's clarification on the use of various models to assist in addressing complex, ecosystem-scale project design questions.